

XLV.—*On the Nomenclature of the Foraminifera.* By Prof. T. RUPERT JONES, F.G.S., W. K. PARKER, F.R.S., and J. W. KIRKBY, Esq.

[Plate XIII.]

Part XIII. *The Permian Trochammina pusilla and its Allies**.

§ I. A minute serpuloid fossil occurring abundantly in the Permian Limestone of the British Islands and Germany attracted the notice of palæontologists twenty years ago. Its tubular and variously contorted shell suggested an Annelidan relationship, though its minute size seemed to contradict that notion. Prof. W. King had, however, from the first, formed the idea of its being related to the Foraminifera; but no near ally among the existing Rhizopods was recognized until 1856, when one of us referred it to "*Spirillina*," which was then supposed to include both opaque and transparent monothalamous shells, either discoidal or twisted †. In 1857 all these together were spoken of as "the *Spirillinae* [hyaline], *Cornuspira* [opaque], and their allies," common in the recent and the fossil state, and as including the minute fossils from the Magnesian Limestone that we have here to treat of (Ann. Nat. Hist. ser. 2. vol. xix. p. 285, & note). Further distinctions had been made by 1860, when the opaque forms were subdivided—some left to *Cornuspira* and others placed with *Trochammina*, the little Permian fossil being provisionally referred to the latter (Quart. Journ. Geol. Soc. vol. xvi. p. 305, note). A similar intimation of its alliance is given in Carpenter's 'Introd. Foram.' (Ray Soc.), 1862, p. 142, and in the 'Monograph of the Foraminifera of the Crag' (Palæont. Soc.), 1866, p. 26. Finally, one of the varieties of this protean Microzoan is so much like a *Miliola* that one of us referred to it, a few years back, as *Miliola? pusilla* ‡.

§ II. Frequently this little fossil occurs as casts in the limestone (as at Humbleton, near Sunderland), and most usually as an oblong coil of white, calcareous, subcylindrical, wire-like folds, with appreciable intervals, especially between the larger, outer folds. A central, irregularly twisted, tubular mass, of about $\frac{1}{50}$ inch in diameter, is enclosed in eight or nine outer folds; these are flat or slightly concave on their

* The last Part of this Series of Papers was inadvertently entitled "Part X. (continued)" instead of "Part XII." See Ann. Nat. Hist. ser. 3. vol. xvi. p. 15.

† In 1854 the discoidal forms alone were referred by one of us (in Morris's 'Catal. Brit. Foss.' 2nd. edit. p. 42) to "*Spirillina*."

‡ 'Synopsis of the Geology of Durham and part of Northumberland,' by R. Howse and J. W. Kirkby, p. 13. 8vo, Newcastle, 1863.

inner and convex on their outer face, and are arranged longitudinally, not all on the same plane, but, with the exception of the outermost folds (which are more nearly parallel), crossing one another at the extremities of the coil at various angles. The size of the folds gradually increases from within outwards, but is subject to irregularities sometimes suggestive of periodic constrictions or undeveloped segmentation. The whole fossil is about $\frac{1}{20}$ inch long, and $\frac{1}{30}$ in breadth and thickness.

Shelled specimens of this kind are abundant in the Magnesian Limestone of Yorkshire ("Lower Limestone," in an old quarry beside an inn called the Hampole Inn), and in the Zechstein of Germany at many places. It is this form which was noticed by Geinitz under the name of *Serpula pusilla*, and by King as *Foraminites serpuloides*.

§ III. These irregularly coiled varieties are accompanied by others that have a more discoidal arrangement of the whorls, which, in this case, fold over and over on one plane or nearly so, making a flatter shell, more or less oval, and leading us as it were to the regularly discoidal narrow-whorled form which was described by one of us, in 1850, as a "*Spirillina*" (in King's 'Monograph of Permian Fossils,' p. 18). The specimen then referred to was from Tunstall Hill, near Sunderland; others have been met with in the Lower Magnesian Limestone of Langton, co. Durham, and elsewhere.

§ IV. Another form of the same kind of shell as the first-mentioned (§ II.) has thicker folds, arranged more flatly on one plane, in an oblong coil, and enveloping one another on their edges, but sometimes showing, on the flatter faces, parts of the early whorls, and thus much resembling some Milioline shells. This is especially abundant near the Hampole Inn above mentioned; and, judging from the section of a shell given as fig. 19, in pl. 10 of Geinitz's 'Dyas,' we presume that it is not wanting in Germany. Among the specimens from Yorkshire, some of the Milioloid varieties become oval, and even circular, differing from the discoidal forms of *Tr. pusilla* only in having thicker, broader, and fewer whorls.

§ V. In 1856 one of us discovered numerous minute "arenaceous" Foraminifera in the shelly sands of the Indian seas, which presented in their contorted tubular forms the required recent analogue of the Permian fossil. Although, indeed, the majority of those first found have a tendency to fold more irregularly than the then known fossil specimens, yet others of the latter have since been abundantly met with, in which the almost discoidal outer folds are disposed to pass for a little way on one of the flatter surfaces of the shell, and then return to their original plane, or even to pass round about

the former whorls of the shell at various angles. On the other hand, the recent contorted forms are associated with others of similar structure and habit, but more or less discoidal in their mode of growth, leading us towards both *Trochammina incerta* (D'Orbigny, sp.) and *Tr. inflata* (Montagu, sp.); and, indeed, all these and other varieties were, in 1860, included under the "second species" of *Trochammina**, as being zoologically related to the typical *Tr. squamata*; but, of course, the necessity of retaining binomial appellations for well-marked varieties, recent and fossil, must be always recognized. For these chief varieties, then, the names *Tr. incerta* (D'Orb.), *Tr. charoides* (P. & J.), *Tr. gordialis* (P. & J.), *Tr. squamata* (P. & J.), and *Tr. inflata* (Montagu) were adopted †.

In a paper "On the Occurrence of Foraminifera in the older beds of the Vienna Sandstone," F. Karrer has given excellent figures of his *Trochammina proteus* ‡ from these strata of Cretaceous or Lower-Tertiary (?) age. Among these figures we find modifications of *Tr. gordialis* (figs. 1, 2, 3, 8), of *charoides* (fig. 4), of *squamata* (fig. 6), and irregular *squamata*, or transitional from lobulate *gordialis* to *squamata* (fig. 5). The Spirilline or discoidal and narrow-whorled condition (*Tr. incerta*), from the same beds, is given as *Cornuspira Hoernesii* (fig. 10).

§ VI. With some of the above-mentioned recent and fossil forms the different specimens of the little Permian fossil under notice are readily correlated. Thus the perfectly discoidal narrow-whorled individuals come in the same group with *Tr. incerta*; and very similar Rhizopods, having plano-spiral shells of sandy texture, have been figured and described from several geological formations, and have received different names, as shown in the following list:—

- Recent. *Operculina incerta*, D'Orbigny, 1839. Foram. Cuba, p. 49, pl. 6. figs. 16, 17.
 Lower Cretaceous. *Operculina cretacea*, Reuss. 1846. Verstein. Böhm. Kreid. p. 35, pl. 13. figs. 64, 65.
 Lias. *Orbis infimus*, Strickland, 1848. Quart. Journ. Geol. Soc. vol. ii. p. 30, fig. a.
 Permian. *Spirillina*, sp., Jones, 1850. In King's Monogr. Perm. Foss. pp. 18–20; and in Morris's Catal. Brit. Foss. 2nd edit. p. 42.
 Chalk and Chalk-marl. *Spirillina cretacea*, Jones, 1854. In Morris's Catal. Brit. Foss. 2nd edit. p. 42.

* Quart. Journ. Geol. Soc. vol. xvi. p. 304. The "first species," or simplest form, has been since referred to the restricted genus "*Webbina*," D'Orb.

† *Op. cit.*, and in Carpenter's 'Introd. Foram.' p. 141, pl. 11. figs. 1–5.

‡ Sitz. Akad. Wien, Math.-Nat. Classe, vol. lii. 1st Abtheil. 1865, pl. 1. figs. 1–8.

- Lias. *Spirillina infima*, Jones, 1854. *Ibid.*
 London Clay. *Spirillina*, sp., Jones, 1854. *Ibid.*
 Recent. *Spirillina arenucea*, Williamson, 1858. Rec. Foram. Brit. p. 93, pl. 7. fig. 203.
 Recent and Fossil. *Trochammina (squamata) incerta*, Jones & Parker, 1860. Quart. Journ. Geol. Soc. vol. xvi. p. 304.
 Recent and Fossil. *Ammodiscus* (species), Reuss, 1861. Sitzungsab. Akad. Wien, vol. xlv. (Zusam. Foram.) p. 365.
 Recent and Fossil. *Trochammina incerta*, Parker & Jones, 1862. In Carpenter's Introd. Foram. p. 141 & p. 312, pl. 11. fig. 2.
 Lower Cretaceous. *Cornuspira cretacea*, Reuss, 1862 (Sitzungsberichte Akad. Wien, vol. xlvi.). Foram. Hils und Gault &c. p. 34, pl. 1. fig. 10, and var. *irregularis*, figs. 11 & 12.
 Tertiary (?). *Cornuspira Hoernesii*, Karrer, 1866 (Sitzungsab. Akad. Wien, vol. lii.), Auftreten Foram. &c. p. 4, fig. 10.
 Permian. *Serpula Roessleri*, Schmidt, 1867. N. Jahrb. 1867, p. 583, pl. 6. figs. 46, 47.

For the distinctive name of this Permian Rhizopod the appellation *Trochammina incerta* (D'Orb.) has priority; whilst zoologically (that is, looking only at its real specific relationship, and taking the *gradations* of form as varietal) it belongs to the typical *Tr. squamata*. For convenience of reference, however, this Foraminifer (Pl. XIII. fig. 1), as in other cases, keeps a distinct name; and we must remark that, as a Permian organism (if its geological age and position are to be regarded as of any special importance), it first received its trivial name (*Roessleri*) from Dr. E. E. Schmidt (1867).

A variety, in which the tube departs, at an early stage, from the spiral to the straight line of growth (this occurs with very many Foraminifers), has been recognized and figured, as *Serpula filum*, by Dr. E. E. Schmidt, *op. cit.* p. 583, pl. 6. fig. 48, who has associated it with the spiral form (both being regarded by him as *Serpula*-tubes), because it also is free and not parasitic.

§ VII. Less regular in its coil, and with a somewhat broader whorl, a closely allied form of this fossil *Trochammina* accompanies the foregoing, and is figured in the annexed Plate XIII. figs. 2 & 3. Still more irregularly folded are figs. 4, 5, & 6, which represent the well-known "*Serpula pusilla*" of Geinitz, the special subject of this notice (see above, § II.). Regarding these as representing a form requiring a distinctive name, though zoologically linked with fig. 1 (by means of figs. 2 & 3), we must, of course, use the long-established trivial name above quoted, and refer to the fossil as *Trochammina pusilla*, Geinitz, sp. We have already remarked that this, with the Spirilline variety, has been included in the zoological species *Trochammina squamata*.

The synonyms of *Trochammmina pusilla* are as follow:—

- Serpula pusilla*, Geinitz, 1848. Verstein. Zechst. Roth. p. 6, pl. 3. figs. 3-6.
Foraminites serpuloides, King, 1848. Cat. Perm. Foss. Northumb. p. 6.
Serpula? pusilla, Jones, 1850. In King's Monogr. Perm. Foss. p. 57, pl. 6. figs. 7-9; pl. 18. figs. 13 a-d.
Serpula pusilla, Morris, 1854. Cat. Brit. Foss. 2nd edit. p. 93.
Spirillina pusilla, Jones, 1856. In King's Memoir on Irish Permian Fossils, Journ. Geol. Soc. Dublin, vol. vii. part 2. p. 73, pl. 1. figs. 12 a, b.
Serpula pusilla, Geinitz, 1861. Dyas &c. p. 39, pl. 10. figs. 15-21, & pl. 12. fig. 1.
Serpula pusilla, Bölsche, 1864. Neues Jahrb. Min. &c. for 1864, p. 667.

§ VIII. Many *Trochammminæ* (*Tr. gordialis* and *Tr. charoides*) from the warm seas resemble *Tr. pusilla*, but more especially in its earlier stage of irregular coiling; and we find individuals of this stage of growth or knot-like condition in the Permian limestone also (see figs. 7, 8); and we can refer to them as *Tr. gordialis*, the synonyms of which are as follow:—

- Trochammmina (squamata) gordialis*, Jones & Parker, 1860. Quart. Journ. Geol. Soc. vol. xvi. p. 304. (*Spirillina pusilla*, Jones, is referred to in the footnote at p. 305.)
Trochammmina gordialis, Parker & Jones, 1862. In Carpenter's Introd. Foram. p. 141.
Trochammmina squamata, var. *gordialis*, Parker & Jones, 1865. Phil. Trans. vol. clv. p. 408. (Reference is here made to the similarity of the so-called *Serpula pusilla*.)
Trochammmina proteus, Karrer, 1866. Ueber das Auftreten von Foraminiferen in den älteren Schichten des Wiener Sandsteins (Sitzungsb. Akad. Wien, vol. lii.), p. 3. figs. 1-8. (Including *Tr. gordialis*, *Tr. charoides*, *Tr. squamata*, and intermediate conditions.)
Trochammmina squamata, var. *gordialis*, Parker, Jones, & Brady, 1866. Monogr. Foram. Crag, p. 26. (Reference is here made to *Spirillina pusilla*, Jones, and *Miliola? pusilla*, Kirkby.)

§ IX. In fig. 9, Pl. XIII., we see broad short whorls making a shell that somewhat reminds us of the Biloculine *Miliolæ*. Still more neatly and compactly arranged, the folds constitute a flattish and nearly oblong shell (fig. 10), or a broadly oval and almost biconvex shell (fig. 11), or even a circular shell with sunken faces (fig. 12). In figs. 13 & 14, the exposure of a circumscribed oval portion of the older whorls in the middle of the side-faces of the subovate shell gives it a particularly Milioline likeness, reminding us of *Triloculina* and *Quinqueloculina*. Hence one of us thought it likely to prove a *Miliola*, and referred to it as *M.? pusilla*; but now we give to this variety the name of *Trochammmina milioloides*. The nearest published drawing is Herr Karrer's fig. 2 of *Tr. proteus*; and indeed it is essentially the same, though showing a greater

exposure of the early whorls, and thus constituting a passage-form between *Tr. gordialis* and *Tr. incerta* in one direction, as *Tr. pusilla* is a link in another.

We may here remark that *Trochammina squamata* (*typica*) has a very near relationship to *Valvulina* in structure and habit, though it possesses more chambers and wants a definite tongue-like appendage at the orifice. This alliance has been suggested to us by our friend and colleague, Mr. H. B. Brady, F.L.S., whose collection of these Foraminifera particularly exemplifies their many intermediate gradations of form. So also *Tr. inflata* sometimes seems to become *Lituola canariensis* by the increased coarseness of its shell and its more compactly nautiloid shape. Indeed there is no real specific, much less generic, distinction between all these and many other associated forms, if such distinctions fade away as gradations of intermediate styles of structure and shape become more and more known.

Again, though the *Miliolæ* have for the most part a homogeneous calcareous shell, yet many become coated with a sandy envelope, and, except in the possession of a tongue or valve at the aperture, may be lineal descendants and representatives of such forms as are here figured in Plate XIII. figs. 9-14; whilst *Cornuspira* and *Spiroculina*, in particular, may in like manner be descended from such as figs. 1-3.

Whether or not the tongue-like process in *Miliola* and the valve in *Valvulina* are essential distinctions, there is no doubt that there is a considerable range of variation in the shell-structure produced by these and other simple Protozoans, and that it is difficult to distinguish the limits between coarseness and fineness, roughness and smoothness, when the amount of sand in the shells of some forms (*Valvulina*, *Miliola*, *Bulimina*, *Textularia*, &c.) varies from much to nothing.

§ X. *Trochammina pusilla* is very widely and very plentifully distributed in the Permian rocks of England and Germany. In Durham it ranges from the lowest beds to the middle of the Magnesian Limestone. It is absent in the highest beds. In Yorkshire it only occurs in the lower beds of the series.

It usually occurs as casts; sometimes (in hard subcrystalline limestone) it is seen as sections showing internal structure, and occasionally as well-preserved testiferous specimens.

In Durham it is found in the "Shell-limestone" at Tunstall Hill, Humbleton Hill, and Claxheugh, near Sunderland.

In the "Lower Limestone" of the same county it occurs at Hartley's Quarry and Pallion near Sunderland, Westoe, Offer-ton, Rough Dene, Eldon, Langton, Morton Timmouth, Sum-

merhouse, Thrislington Gap, Running Waters, Moorsley, Walworth and Limekiln Banks, south of Leg's Cross.

In Yorkshire it is very abundant, occurring, with the Milioloid variety, in myriads, in the dark-grey limestone of Nosterfield, and in a similar limestone at Chapel Houses,—also at Gybdykes, near Masham, Thornton Watlass, Linderick, and Hampole.

In Ireland it has been found by Prof. W. King at Tullyconnel Hill, near Artrea, co. Tyrone.

In Germany it is very common in the Lower Zechstein of Corbusen, near Ronneburg, and at other places in the vicinity of Gera, at Moderwitz (near Neustadt) on the Orla, at Kamsdorf and Saalfeld, and in the Wetterau ('Dyas,' p. 40). It is found also in the "grauer Mergel-Zechstein," overlying the Zechstein at Gera (King, Journ. Geol. Soc. Dublin, 1856).

The discoidal or *Spirillina*-like form (*Tr. incerta*) is found in Durham in "Shell-limestone" at Tunstall Hill, and in "Lower Limestone" at Langton, Thrislington Gap, Walworth, and Limekiln Banks, south of Leg's Cross.

The Nosterfield limestone, when cut and polished, shows instructive sections, the matrix being almost black, while the shell-substance is white. This rock is similar to the black limestone of Gera and Hanau.

This little fossil is always associated with other fossils, such as *Producta horrida*, *Gervilia antiqua*, and *Ichthyorachis anceps*, often with other Rhizopods, and as often with an obscure plant-like fossil which has been named *Chondrus virgatus*. It is always free (not attached or parasitic); and we do not see any reason to follow Dr. Geinitz* in associating the fixed vermiform fossil (*Vermilia obscura*, King) with *Trochammina pusilla*.

EXPLANATION OF PLATE XIII.

Fig. 1. *Trochammina incerta*. From Langton, co. Durham. Magnified 30 diameters.

Figs. 2, 3. *Tr. pusilla*, subdiscoidal forms. Sunderland. Magn. 15 diams.

Figs. 4, 5, 6. *Tr. pusilla*, ordinary forms. Sunderland. Magn. 15 diams.

Figs. 7, 8. *Tr. gordialis*. Tunstall Hill, Sunderland. Magn. 15 diams.

Figs. 9-14. *Tr. miholoides*, various forms. Sunderland. Magn. 10 diams.

Fig. 15. *Tr. pusilla*, section. Nosterfield. Magn. 15 diams.

* 'Dyas,' p. 39. In the 'N. Jahrbuch &c.' for 1864, p. 667, Herr Bolsche also noticed a serpentine form, parasitic on shells &c., and intimated that it and King's *V. obscura* may be the same as, or varieties of, the coiled form.